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OF A NEW CLASSIFICATION OF THE LEPIDOPTERA.

BY A. S. PACKARD.

(*Continued from page 647*).

Remarks on the Family Hepialidæ.—This group is assigned by Comstock, from the venation alone, to a position at the bottom of the Lepidopterous scale, even below the Micropterygidæ. By Chapman it is more correctly placed above the latter group. He even places it above the Nepticulidæ, Adelidæ and Tischeria.

Since receiving and studying Chapman's paper, it has become very plain to me that Hepialus and its allies are simply colossal Tineoids, and that Speyer was right in 1870 in suggesting that the Hepialidæ stand very near to the Tineids.[1]

These views arrived at independently by these authors are confirmed by the trunk characters, and also by the larval characters, as pointed out by Dyar,[2] and which I have been able to confirm by an examination of the freshly hatched larva of *Hepialus mustelinus*, and fully grown larvæ of the Australian *Oncopera intricata* Walk., as well as *Hepialus humuli* and *H. hectus* of Europe.

In 1863 I pointed out[3] the similarity in the head and thorax of *Hepialus* (Stenopis) *argenteomaculatus* to those of the neuropterous Polystœchotes, and mentioned the elongated thorax of Hepialus, especially "the unnatural length of the metathorax, accompanying which is the enlarged pair of wings, a character essentially neuropterous." Reference was also made to the metascutum which is divided into two halves, being separated widely by the very large triangular scutellum. I also drew attention to the transverse venule or spur of the costal vein, and to the great irregularity in the arrangement of the branches of the median nervure, also to the elongated abdomen, and, finally, I remarked, "The Hepiali are the lowest subfamily of the Bombyces." But in those days I did not fully perceive the taxonomic value of these generalized characters, which have so well been proved by Chapman from imaginal and pupal characters, and by Comstock from the venation, to be such as to place the Hepialidæ at or near the base of the Tineoid series. Chapman, unaware of the existence of mine and of Speyer's paper, says: "The metathoracic structure of Hepialus came as a very unexpected confirmation of the idea that of the Tortricoid group, it was the nearest to the lower Adelids, and despite its specialization was near the line by which Tortrix was derived from some Adelid form." (P. 113.)

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[1] In his suggestive paper (Ent. Zeit. Stettin, 1870), Speyer refers to the similarity of the venation of Hepialidæ and Cossidæ and remarks that they resemble the Trichoptera no less than the Micropterygidæ, though the Hepialidæ exhibit other close analogies to the Trichoptera. He adds that the middle cell of the wing in the Phryganeidæ is not fundamentally different from that of the Hepialidæ, Cossidæ, and Micropteryx, also the hind wings of Pychidæ. On p. 221 he associates the Zygænidæ with the Cossinæ, Cochliopodidæ, Heterogynidæ, Psychidæ and Hepialidæ, and remarks that all these families are isolated among the Macros; the Cochliopodidæ and Zygænidæ alike in the pupa state by the delicate integument and the partially loose sheaths, the groups standing nearest to the Tineidæ with complete maxillary palpi, forming the oldest branch of the lepidopterous stem, and having been developed earlier than the Macros.

[2] A classification of Lepidopterous larvæ. Annals N. Y. Acad. Sci. viii, 1894, p. 196.

I will now refer to some characters of the Hepialidæ which further show that they are colossal Tineoids, and should be placed very near the base, though still presenting in their boring larval habits, and in the reduced maxillary and labial palpi, the entire absence of a haustellum and of mandibles, that the family (at least Hepialus and Stenopis) have undergone a considerable degree of modification, compared with the Micropterygidæ.

Beginning with the larva, that of the Australian *Oncopera intricata,* when compared with the larva of the colossal Tineid *Maroga unipunctaria* of South Australia, is the same in structure, though less specialized in the colors of the tubercles and in the sculpturing of the head, but it has the same shape of the body, the same arrangement of the 1-haired tubercles, though the setæ are smaller and shorter; and the same complete circles of crochets on all the abdominal legs.

[3] On synthetic types in insects, Boston Jour. of Nat. Hist., 1863, pp. 590-603.

In the freshly hatched larva of *Hepialus mustelinus* 1.3 mm. in length, the head is no wider than the prothoracic segment, whose dorsal plate is well developed. The mouthparts are quite large, especially the spinneret, while the hairs which are acute at the end, are in this stage as long as the body is broad. The abdominal legs appear to have at this stage only ten crochets, or at least very few.

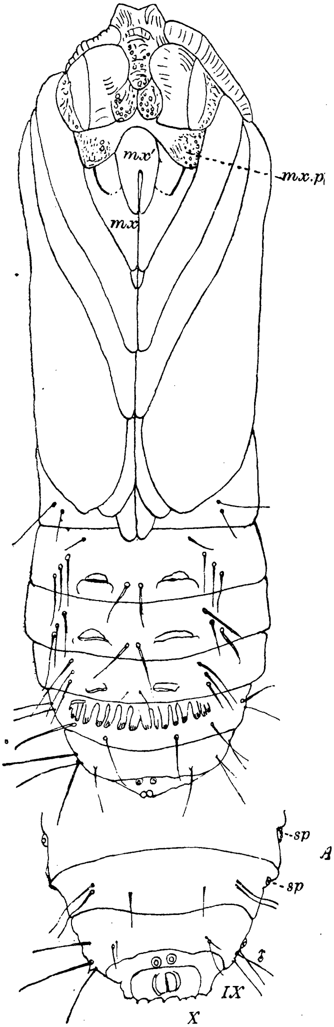

FIG. 7.

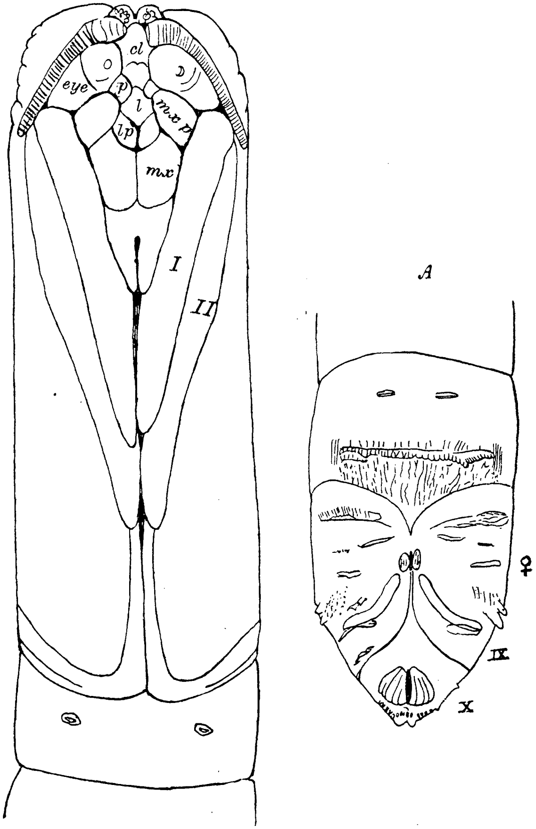

FIG. 8.

The pupa of Hepialus is said by Chapman to differ from that of Tortrix " in having the third abdominal segment free, but in a peculiar and modified manner," etc. He does not refer to the mouthparts. I have not seen the pupa of Hepialus, but have examined the pupa of the Australian *Oncopera intricata* (Fig. 7), and of the Mexican *Phassus triangularis* H. Edw., both of which present some remarkable generalized features. In the former genus, the labial palpi are visible, the entire piece is very wide at the base and is divided at the middle into the two pupal cases. Between it and the deeply lobed labrum is a piece, unless the two lobes are the paraclypeal pieces, of the nature of which I am uncertain. It is the homologue of the eye-collar, and if so, are the two lateral portions the maxillary palpi? The maxillæ themselves (*mx.*) are well developed, but at their base are divided by an impressed line, representing a portion which I am unable to name. The three pairs of feet (I, II, III) are easily identified. The outer division of the eye is large; and the cocoon-breaker consisting of two solid thick ridges on the vertex adapted for breaking out of its cell in the tree it inhabits, is marked. Abdominal segments 3–7 are free in ♂, and on 3 to 6 is a row of spines at each end; on segments 7 and 8 there are four transverse rows of stout spines, and on 9 two rows of small spines. There is no cremaster. On the under side of segment 8 is a row of about 15 stout spines. Vestiges of three pairs of abdominal legs are distinct. The pupa is provided on the abdomen segments with a few long setæ.

The pupa of Phassus (Fig. 8) is remarkable. The larva bores into a very hard tree, according to the late Mr. Henry Edwards, who kindly gave me a specimen of the pupa. The head is remarkably adapted for its life in a cell, being broad, obliquely truncated, the small antennæ being protected by the flaring sides of the head, which is very solid, with numerous rugosities and small tubercles. The region about the mouth is remarkable. The clypeus and labrum are very narrow, the eye transversely elongated, with an impressed line in the middle. The eye-collar (*mx. p*) is distinctly separated from the maxillæ (*mx*).

The two pieces (*l p*) at the base of the maxillæ may possibly prove to be the labial palpi, if so, is the piece marked *l* the labium? The two paraclypeal pieces or tubercles (*p.*) appear to be the homologue of those in the Psychidæ.

The pupæ of this family are very extraordinary, but it will be seen that they are Pupæ incompletæ, and prove that the family should stand much above the Micropterygidæ, rather than below them, so far as regards pupal characters.

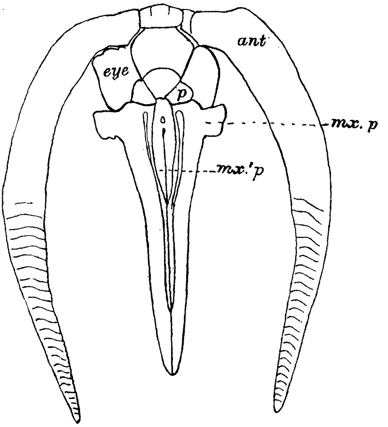

FIG. 9.

Fig. 9 shows the front of the head and maxillæ of the Cossid, *Prionoxystus robiniæ*, which is more Tortricid than Hepialid; *pc*, paraclypeal piece; *mx. p*, maxillary palpi; *l*, labial palpi; *mx*, maxillæ.

The very primitive, generalized shape of the thorax of the Hepialidæ is noteworthy. In *Hepialus mustelinus* the collar or prothorax is very much reduced; while in *H. tacomæ* it is very long and generalized, as in Sthenopis and the Australian *Abantiades argenteus*. The mesoscutum is considerably shorter than in *H. tacomæ*. In the latter species the metascutum is entirely divided by the large scutellum, while in *H. mustelinus* it is only partly divided, the apex of the scutellum passing a little beyond the middle of the scutum.

It is thus quite evident that Sthenopis is an earlier form than *H. tacomæ*, and that the latter is more generalized, having undergone less modification than *H. mustelinus*.

The genus Hepialus occurs in Australia, and that continent appears to be the original home of the family. In *Abantiades argenteus* the antennæ are tripectinate, and the labial palpi are very large; in *Hectomanes fusca* the antennæ are bi-pectinated but the labial palpi are much reduced, being scarcely visible; while *Oncopera intricata* is remarkably modified; though the antennæ are simple, the eyes are very large, nearly meeting on the front, while the 3-jointed labial palpi are remarkably long and slender, extending upwards, and the hind legs have a remarkable broad, flattened, curved pencil of hairs.

It thus appears that in the Australian continent this interesting family, which may be a survival of Jurassic times and coeval with the marsupials, has branched out along several lines of specialization, the most degenerate form being Hepialus which has survived also in Europe and in North America, especially on the Pacific Coast. On the whole, however,

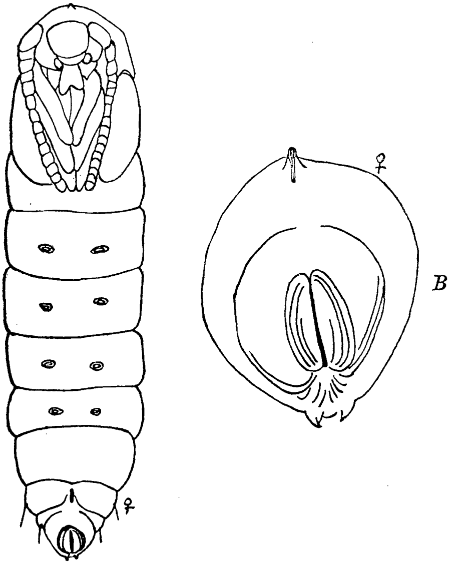

FIG. 10.

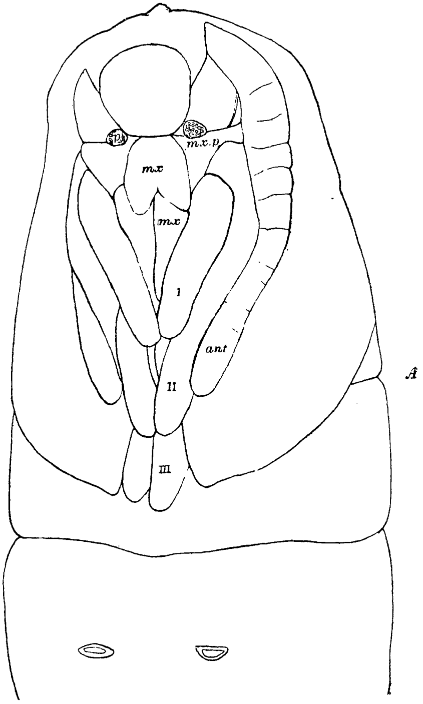

FIG. 10 A.

as we have seen, it is not so generalized a group as the Micropterygidæ, a group common to Europe and North America.

Its relations to the Cossidæ, including the Zeuzerinæ, remain still to be elaborated ; they are rather close, yet the Tortricoid affinities are very apparent, and need further examination. The pupa of *Zeuzera pyrina* is of the same character as in Prionoxystus, but the maxillary palpi are larger, the lateral palpi more reduced, while the cell-breaker is very long, being much more developed.

Family Talæporidæ.—This group, comprising the genera Solenobia and Talæporia, have evidently either directly descended from the case-bearing Tineidæ or the two families have had a common origin. They form a side branch by themselves and are evidently the immediate ancestors of the Psychidæ. The imagines have no maxillary palpi, and the tongue is wanting, whilst the females are wingless. They are tineid Bombyces. In the pupal characters (Fig. 10, *Talæporia pseudobombycella*, pupa, A, head enlarged ; B, end of body) the group very closely resembles the Psychidæ. Perhaps the slight changes in venation and the much greater breadth of the wings, as well as the pectinated antennæ of the Psychidæ, are the result of adaptation to the stationary mode of life of the females (Fig. 11, *Solenobia walshella*, head of pupa ; A, end of body).

Family Psychidæ.—An examination of the pupæ of several genera of this family, convinces me that it belongs among the Tineoids, and that Chapman and also Comstock have rightly removed them from the Bombyces. I should place them in the neighborhood of the Tineoid genera Solenobia and especially Talæporia, the venation of the latter genus being, as shown by the figures in Spuler's[4] paper, almost identical with that of Fumea and Psyche. Without, at this time, referring to the larva of the highly modified wingless female, or to the characters of the adult male, I will simply call attention to some points in the structure of the pupa of different genera of the group, which indicate their very generalized nature.

The pupa of *Thyridopteryx ephemeræformis* has a close resemblance to that of *Oncopera intricata,* as will be seen by the presence of a large median piece or area between the base of the maxillary palpi. In *Œceticus abbotii* (Fig 12) the maxillary palpi are separated by the second maxillary (labial) palpi; the former (*mx p*) is subdivided into an inner and an outer small lobe in another European Psyche; also in *Platœceticus gloverii.* In the Psychidæ the paraclypeal pieces or tubercles, as we might call them, are always present. They are convex and very rugose. The labium or second maxillary piece in the Australian *Eumetopa ignobilis* is of the same shape and sculpturing as in *Psyche graminella,* but the large round rugose pieces on each side, or first maxillary palpi, are single, not divided into two parts, unless the irregularly trapezoidal pieces between the maxillary palpi and the eye-piece be the homologue of the outer portion.

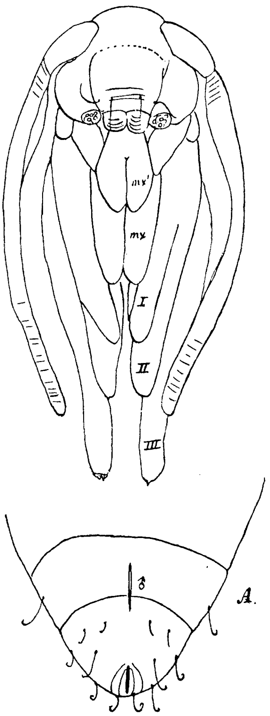

FIG. 11.

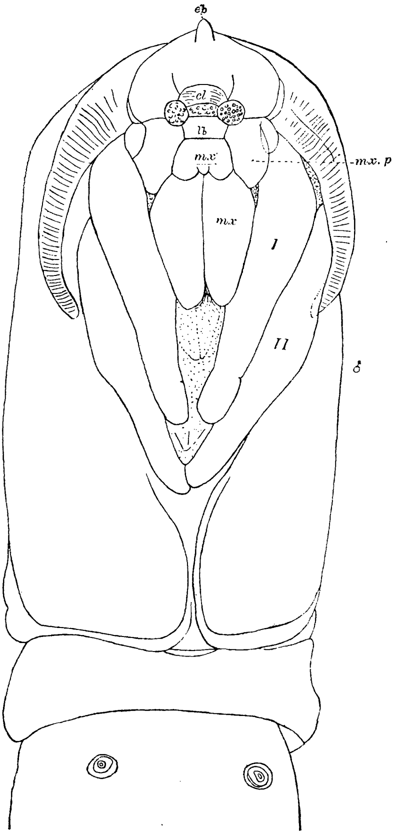

FIG. 12.

In the Australian *Metura elongata* the short reduced labial palpi are much as in *Psyche graminella,* but are more deeply divided; the two divisions or lobes I am inclined to consider as the second maxillary (labial) palpi. In this genus the first maxillary palpi are also as in *Psyche graminella.*

It will thus be seen that in the pupa of this family the first and second maxillary palpi vary very much in form, as they probably do in the imagines, being more or less atrophied in the latter, where they need to be carefully examined. On the other hand, the maxillæ themselves (for in their pupal condition in haustellate Lepidoptera they have retained the separated condition of the laciniate Lepidoptera) though short are quite persistent in form. The pupa of *Platœceticus gloverii* differs from that of *Œceticus abbotii* in the undivided first maxillary palpus (eye-piece), and the elongated second maxillæ, as well as the narrower clypeal region, and the lack of a cocoon or case-opener.

By an examination of the figures it will be seen that the outer division of the eye-piece varies much in size; this is due to the varying width of the male antennæ, which, when wide, as in Pinara (Entometa), Metrua, Thyridopteryx and Psyche, overlap and nearly conceal it, while it is entirely hidden in Platœceticus. On the other hand in male pupæ of Hepialus and Oncopera, where the antennæ are small, narrow and not pectinated, these pieces are large. The end of the body has no cremaster, but what is unique, a hook arising from each vestigial anal leg.

Finally it will be readily seen that from an examination of the pupæ, the views of Speyer, of Chapman, and of Comstock, as to the position of the Psychidæ is fully confirmed, while I should go a little further and place them still nearer the Hepialidæ. They are, however, still more modified than this last named group, since the females are wingless and limbless. It is very plain that they are an offshoot from the Tineoids, and especially from the Talæporidæ which have no tongue and whose females are wingless and sackbearers.

Remarks on the Cochliopodidæ.—Chapman removes this group from the Bombyces from a study of their larval and pupal characters. We should, after studying the pupæ of five or six genera, agree with his suggestion that this and the family Megalopygidæ (Lagoidæ) should be removed from the Bombyces and placed near the Tineoids, from which they have undoubtedly descended. That the line of descent, however, was directly from the Eriocephalidæ seems to us a matter of doubt. The larvæ of the Cochliopodids present some notable differences from that of Eriocephala, whose so-called "eight pairs of abdominal legs" appear to be merely spine-bearing tubercles. Although the head of Eriocephala is partially retractile, this adaptation may have no phylogenetic significance.

Figure 13 represents the front of the head of *Parasa chloris*, showing the maxillary palpi and a lateral process connected with it, which I have not seen in any other pupæ, and may be internal. I have also observed it in the cast pupal skin of *Tortricidia testacea.* The maxillæ are either shorter or no longer than the large labial palpi. The paraclypeal tubercles are well developed in this group.

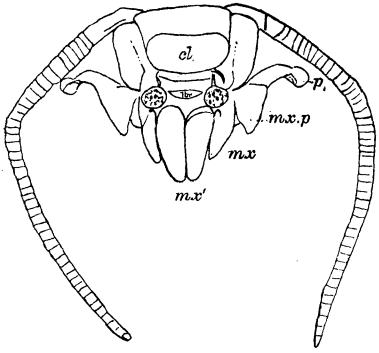

FIG. 13.

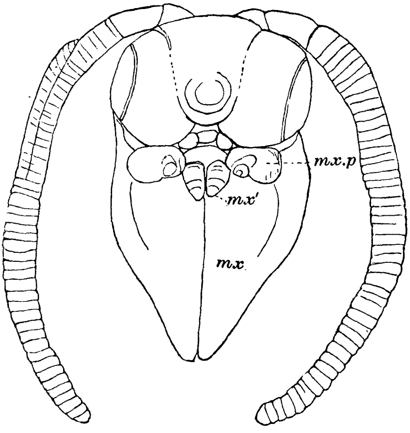

FIG. 14.

Remarks on the Megalopygidæ.——The genus Megalopyge (Lagoa) is remarkable for the shape of the pupa, which is somewhat as in Cochliopodidæ, confirming the view that the two families are allied, though still presenting some notable differences in larval characters. Figure 14 represents the pupal features as seen in the front of the head of a Megalopyge from

Florida (probably *M. crispata* or *opercularis*). The maxillæ seem to be aborted; on each side of the 2d maxillary (labial) palpi under the eye, are the 1st maxillary palpi, whose structure needs farther examination.

The last division of Lepidoptera (*Pupae obtectæ* of Chapman) mostly comprises the specialized broad-winged modern or macropterous forms, though including many of the specialized Tineina.

The next series of families begins with the *Tortricidæ*, from which may have descended the Cossidæ. As will be seen by comparing the pupa of *Tortrix rileyana* with that of the Cossidæ (fig. 9, head and mouth parts of the pupa of *Prionoxystus robiniæ*) Dr. Chapman's opinion that Cossus has "no characters at any stage to distinguish it from Tortrices," is well sustained. The pupal characters of *Zeuzera pyrina* also show that it belongs to the same family as Cossus and its allies. In the Cossidæ there is no separate pupal maxillary palpi, the lateral flap (*mx. p.*) not being separate. The labium and its palpi are long and narrow, as in Tortrix. The paraclypeal pieces are distinct.

The point of departure of Tortrididæ from the Tineina has still to be worked out; it must have been some generalized genus in the pupa of which the eye-collar (maxillary palpi) and labial palpi were well developed.

Here might be placed the two families Thyrididæ and Sessiidæ. After a reconsideration of the transformations of these groups, we agree with Dr. Chapman that as regards the latter "it is a 'Tineoid' in spite of some Tortricid characters." We should, however, not absolutely place the family in the Tineina, but should rather regard it as an immediate descendant from some Tineoid genus with a well developed eye-collar and with a well developed labium. Its generalized nature is also shown in the large distinct paraclypeal pieces. The two families have evidently directly descended from some Tineoid, but they have become much modified and specialized, especially in the venation, and form a side branch of the Tineoid series with absolutely no relation to the Sphingidæ, near which they are usually placed. We have been unable to obtain the pupa of Thyris for examination.

Family Zygænidæ.—Another group supposed by Spuler[4] (venation) and also Chapman (pupa) to be closely related to the Tineoids is the Zygænidæ, from which I should separate the Syntomidæ. The pupa of Zygæna is said by Dr. Chapman to possess " ill-developed eye-collars (maxillary palpi)," and the dehiscence is typically incomplete. I have been unable in the specimen kindly given me by Dr. Chapman to detect the ill-developed eye-collar, but the cast pupa skins examined are not well preserved, and these pieces may be detected in living or alcoholic specimens. Comstock places the Zygænina high up remote from the Tineina, but at present I am disposed to regard the Syntomidæ as a distinct group with a different origin, and more nearly related to the Arctiidæ. I fully agree with Chapman that Zygæna is near the Tineina; and I agree with Comstock that Triprocis and Pyromorpha have " a remarkably generalized condition of wing-structure."

The true Zygænidæ form a side branch or somewhat parallel group. I should regard Ino (Triprocis) as a more generalized genus than Zygæna. Judging by the venation, Harrisina has undergone a little more modification than Ino. Pyromorpha also seems rather more primitive than Zygæna. I see no reason for regarding Pyromorpha as the type of a distinct family.

I have only the pupæ of *Harrisina americana* and of Zygæna to examine, but judging by this scanty material, that of Harrisina seems to be the more generalized form, that of Zygæna the more specialized. As Zygæna does not occur in America, but is Eurasian, it is possible that in its generalized Zygænid fauna America, as in other groups of animals, has lagged behind Europe, Zygæna with its numerous species being a more advanced or specialized type brought into existence by more favorable conditions.

Origin of the Lithosiidæ.—It seems to me that the group of forms usually referred to the Lithosiidæ but which are nearest to the Tineina, is that represented by Enæmia (Eustixia, Mieza), Oeta and Tantura (Penthetria) as the imagines of these genera, whether we consider the shape of the head and body, antennæ and legs, or the venation and shape of the wings, are the nearest to the Tineidæ and appear to form a family of Tineoid moths. Indeed Enæmia is now referred to the Tineina of the family Hyponomeutidæ, and possibly the Lithosiidæ originated from this family or from a group standing between them and the Prodoxidæ.

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[4] Zur Phylogenie und Ontogenie des Flügelgeaders der Schmetterlinge. Zeits. wissens. Zoologie, 1892.

The pupæ have the long narrow head and eyes of Tineina. The eye-collar is wanting, but vestiges of the labial palpi are present, and also vestiges of the paraclypeal pieces. Judging by the venation, Enæmia is the more generalized, and Tantura the more modified genus. The pupa of *Oeta aurea* (fig. 15) in the head characters is rather more generalized than that of Tantura, the labial palpi being a little larger and the base of the maxilla more flaring, as if forming rudimentary eye-collars or palpi, but the abdomen and its end is much more specialized than in Tantura, as it is long, slender, conical, and ends in a well developed cremaster provided with curved setæ adapting it for retaining its hold in its slight cocoon. In general appearance and markings it is like a Geometrid pupa, having black longitudinal stripes. In the pupa of Tantura the shape of the abdomen is more generalized, there being no cremaster, but hooked setæ enabling it to retain its hold within its beautiful loose, basket-like cocoon.

It is probable that these genera descended from some broad-winged Tineid and possibly from the same stem-form as the Prodoxidæ, as the venation is somewhat similar. Hyponomeuta and especially Argyresthia appear to be later, more specialized forms. This group (Enæmia, Oeta, and Tantura) almost directly intergrades, judging from the venation, with the Lithosiidæ, Byssophaga, Cisthene, and Crocota, connecting them with Lithosia; though the larvæ of the latter are much more specialized and arctiiform. Hence the line of descent from the generalized Tineina to Enæmia, Oeta, Tantura, to the Lithosiidæ, and from them to the Arctiidæ, is more or less direct. It is interesting to note the gradual widening of the wings, especially the fore-wings, as we pass from Lithosia to Arctia, also to notice the gradual change in the larval and pupal characters, those of the Arctian pupæ being slightly less primitive than in the more generalized Lithosiidæ. It is also interesting to note that in ascending from the Tineoid precursors of the Lithosiidæ to the members of the latter family, we pass from incomplete to complete pupæ showing that the division into pupæ incompletæ and obtectæ may be at times artificial.

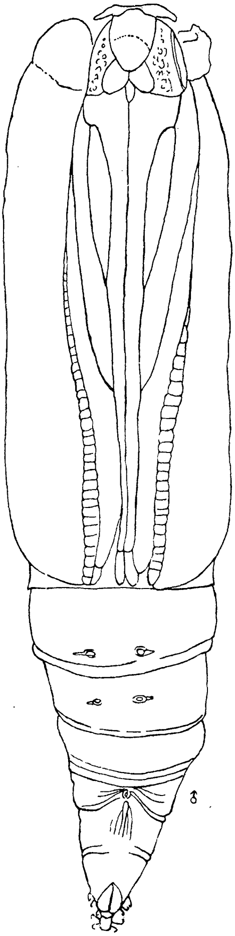
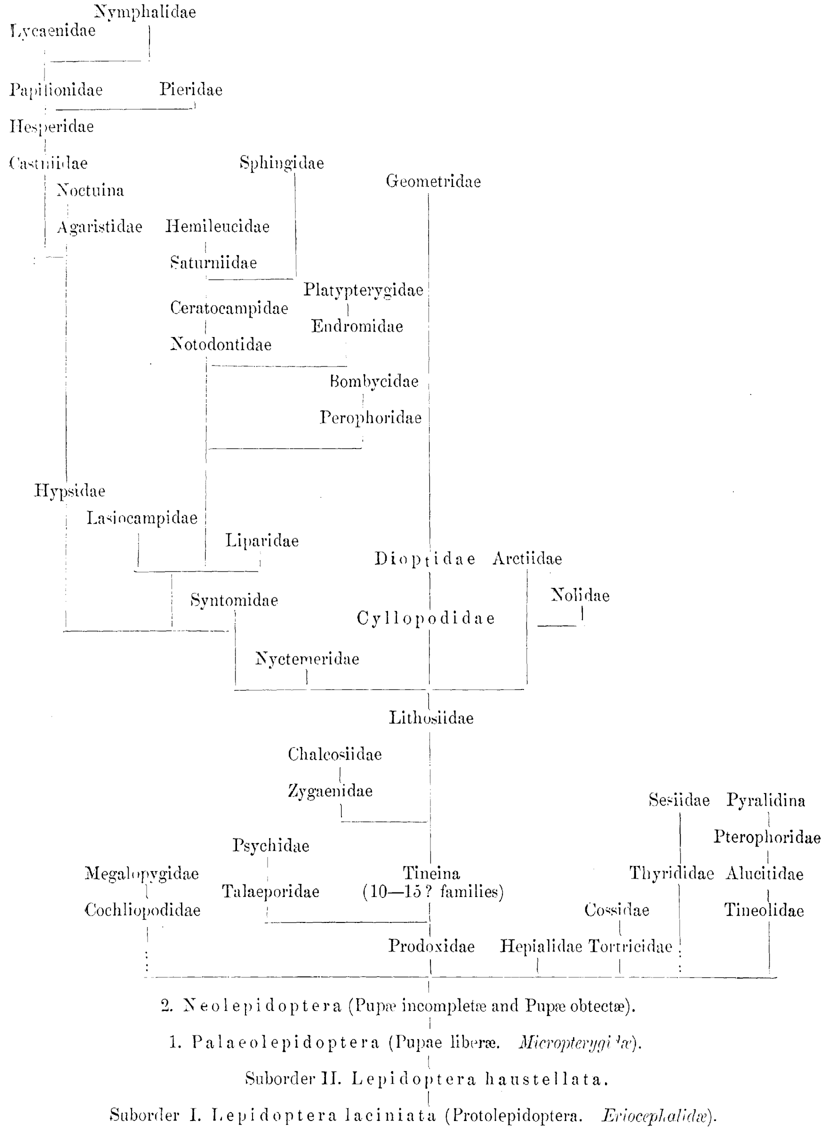


FIG. 15.

Family Nolidæ.—The structure of the pupa of Nola (*N. ovilla*), besides its larval and adult characters, convinces me that the genus is the type of a distinct family, and forming a line of descent somewhat parallel with and near to the Lithosiidæ. The pupa has the labial palpi well developed, and the paraclypeal pieces large. The end of the abdomen is rounded and unarmed, in adaptation to its enclosure in a dense cocoon.

Family Syntomidæ.—The position of the Syntomidæ is difficult to determine. The pupa is obtected, though it has in Scepsis retained the labial palpi. Judging by the larval and pupal characters the family stands much nearer the Arctiidæ than the Zygænidæ, but yet is more generalized than the former. In the venation the group stands near the Arctians, i. e., the venation of the generalized *Ctenucha* approximates that of *Epicallia virginalis*, while in Didasys and Syntomis the venation is more aberrant and modified; so also in the long tufted larvæ of Syntomis and Cosmosoma, compared with that of Ctenucha, in which the tufts are less developed and specialized.

On the following page is a provisional genealogical tree of the order, based mainly on the pupal and imaginal characters.


Nymphalidae
Lycaenidae
Papilionidae
Pieridae
Hesperidae
Castniidae
Noctuina
Agaristidae
Sphingidae
Geometridae
Hemileucidae
Saturniidae
Platypterygidae
Ceratocampidae
Endromidae
Notodontidae
Bombycidae
Perophoridae
Hypsidae
Lasiocampidae
Liparidae
Dioptidae
Arctiidae
Nolidae
Syntomidae
Cyllopodidae
Nyctemeridae
Lithosiidae
Chalcosiidae
Zygaenidae
Sesiidae
Pyralidina
Pterophoridae
Psychidae
Megalopygidae
Tineina (10—15? families)
Thyrididae
Alucitidae
Talaeporidae
Cochliopodidae
Cossidae
Tineolidae
Prodoxidae
Hepialidae
Tortricidae
2. Neolepidoptera (Pupæ incompletæ and Pupæ obtectæ).
1. Palaeolepidoptera (Pupae liberæ. *Micropterygidæ*).
Suborder II. Lepidoptera haustellata.
Suborder I. Lepidoptera laciniata (Protolepidoptera. *Eriocephalidæ*).